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# Summer comfort and cooling: calculation methods and requirements

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Summer comfort and the energy consumption for cooling are a growing point of attention, not only in Mediterranean climates, but also in the more moderate summer climates of central and northern Europe. This paper summarizes the results of a survey of a dozen European countries with respect to the handling of these aspects in the national/regional EPB-regulations.

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## 1 > Survey method

Until recently, the focus of many EPB-regulations and much standardisation work has more strongly been on the energy consumption for space heating. However, in recent years growing attention is being given to the aspect of summer comfort (if possible without active cooling) or to the energy consumption caused by cooling. Nevertheless, it is clear that, generally speaking, the methods for summer comfort and cooling are not yet as advanced as the methods for space heating, where several decades of operational experience have led to proven and mature calculation methodologies and requirements.

In the framework of the IEE-ASIEPI project an inventory has been made of the state of the following aspects in the EPB-regulations of several European countries:

- the way in which the energy consumption for cooling is calculated
- the way in which summer comfort is evaluated, if at all
- any explicit requirements that are imposed with respect to summer comfort and/or cooling

The main findings are summarized in this paper. The following countries have been surveyed: Belgium, Germany, Spain, France, Greece, Italy, the Netherlands, Poland (state in the summer of 2008), and in a second round additionally Hungary, Ireland, Lithuania, Romania and UK (state in the winter of early 2009). Sometimes the answers referred to draft calculation procedures or legislations that were not yet in force.

There were no Scandinavian countries in the survey, as it was thought beforehand that cooling and overheating were not an issue in this climate. Nevertheless, these countries afterwards orally reported that summer comfort is becoming a growing point of attention in this region too. They attribute this to different factors: larger glazing areas in recently constructed buildings, the mild outdoor summer temperatures that lower the acceptable indoor comfort temperature for overheating (adaptive comfort) and the long summer days with low solar positions generate a lot of solar gains.

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It goes without saying that the EPB-regulations in the different countries are still in full change. This is all the more true for a relatively new domain such as summer comfort and cooling. This paper therefore gives only a snapshot of a rapidly evolving situation.

During the survey, it has been observed that a lot of misunderstandings occurred among the different countries when exchanging information. Although this is a more general experience when exchanging international experiences with respect to the EPBD, the problem proved to be particular difficult for cooling. In part, this can be ascribed to the fact that until recently there was little international standardisation that provided common concepts and uniform terminology. It is hoped that as the sector gradually becomes more familiar with the new European standards, this communication problem will become less severe.

## 2 > Calculation methods: cooling

This paragraph gives a succinct overview of the situation in the different countries at the time of the enquiry. The inventory has focussed on the variables that enter as input in the calculation methods: these determine the degree of design freedom and the stimuli that the EPB-regulation generates.

The full information collected on this topic can be consulted in ref. [1].

### General features

At the time of the enquiry 9 out of 13 countries reported to have already an EPB-regulation in place. Countries without were mostly situated in southern and eastern Europe, but most of them were working intensely on the preparation of a regulation. In the remainder of this chapter only the 9 countries with an EPB-regulation will be considered. In a few instances, the EPB-regulation related only to housing but not (yet) to (all) non-residential buildings, or vice-versa.

In line with the EPBD, in the 9 countries with a regulation, the consumption for cooling is always taken into consideration, albeit sometimes in an incomplete way or in a manner that is to a greater or lesser extent simplified. Monthly calculations were used in 5 cases, hourly in 4. Each time, the same method (monthly or hourly) is used for both the building and the system calculations.

Only in 2 out of the 9 countries is the EPB-requirement relaxed if cooling is applied, i.e. an extra allowance for the cooling is provided. In the other countries, the extra consumption for cooling must thus be compensated by better energy efficiency in other areas such as heating, lighting, etc.

In 4 countries there is some form of fictitious cooling consumption considered if no active cooling system is installed, e.g. in the instance when the risk of overheating is considered to be too high. This may be a sort of anticipation that active cooling could be installed later in the course of the building life cycle when the overheating problems manifest themselves. Ref. [1] gives an English description of the method as applied in Belgium. By already including such fictitious cooling from the start, designers are stimulated to pay proper attention in each and every one of their projects to the summer behaviour of the building.

### Calculation methods: energy needs

The input variables in the 9 countries are as follows:

- thermal mass: all countries consider sensible heat storage, albeit sometimes in a simplified manner. But none includes latent heat storage (through phase change materials) as yet.
- solar irradiation: apart from 1 country, all determine direct, diffuse and ground reflected radiation separately.
- solar gains through transparent envelope components: obviously, the g-value of the glazing, the area, slope and orientation of the windows and the shading by fixed objects are (quasi) always considered. All 9 countries also report that solar protection devices, both mobile and fixed ones, are taken into consideration.
- solar gains through opaque envelope components: 5 countries report that these are (partly) taken into account, e.g. for non-residential buildings and/or roofs only. In such instances, the absorptance and U-value are usually input variables (but sometimes the absorptance is fixed).
- transmission heat transfer: only 2 countries report that the calculation is different between winter and summer calculations. In Belgium, in the case of a simple penalisation of thermal bridges, the default value (which as a matter of principle is always negative) is different: high in winter, zero in summer. In the Netherlands, the ground losses are treated differently in winter and summer.
- heat transfer through the hygienic ventilation system: only 5 countries report that air handling units are calculated on the basis of a separate heat balance, although obviously this is physically important. If calculated by itself, sensible and latent cooling and reheat are then generally considered in detail. In both these and in the other countries, heat exchanger by-passing, direct or indirect evaporative cooling, night-time operation or ground heat exchangers are only occasionally considered.
- heat transfer through intensive ventilation: although this is a major means of removing excess heat (only at night on hot days, both during the day and at night on mild days), only 4 countries report to have it in the calculation method, but mostly in a strongly simplified, nearly fixed manner. Only France includes detailed input variables such as the area of the (supply and evacuation) openings (or stacks) and their flow characteristics, and mechanical extraction (including its electricity consumption).
- heat transfer through in/exfiltration: usually the airtightness is considered when calculating the consumption for cooling, and generally speaking a measurement of the airtightness can then serve as an input (instead of a default or estimated value). In only 3 countries the default value is reported to be different between heating and cooling calculations. In Belgium for instance, it is 12 $m^3/h/m^2$ of envelope area (i.e. very leaky) for space heating calculations and 0 $m^3/h/m^2$ (i.e. the theoretical limit value of perfect airtightness) for space cooling calculations, in line with the general philosophy of a default value.

### Calculation methods: systems

The great variety of distribution and emission systems is not always included in the method, and if so, often in a simplified manner. Sensible thermal cold storage (e.g. chilled water tanks) is only considered in 2 countries, latent storage (e.g. ice banks) nowhere.

The generation efficiency of a cooling machine is usually included as a matter of principle, but sometimes in a very simplified manner such as a fixed value. Otherwise, a machine dependent EER or SEER is used.

If sorption cooling is considered at all, it is usually only for closed cycles. Open cycles (such as desiccant cycles) are only rarely integrated in the calculation method. In both instances, heat supply with conventional boilers or direct firing, cogeneration or district heating is commonly considered, but solar heating only rarely.

Passive means of centrally (i.e. in parallel with, or fully replacing cooling machines) disposing of excess heat are considered in a very variable manner. Surface water (from river or lake or sea) as natural heat dump is never considered in the standard calculation method. Heat rejection to the ambient air by means of a dry or wet cooling tower is only considered in 2 countries. Only 3 countries consider the ground (by means of ground water, closed-circuit boreholes, heat exchangers in pillar foundations) as heat dump in the standard method. Radiative cooling to the night sky (which is only effective in dessert-like conditions, with clear, dry night skies) is not considered in the calculation method of any European country.

Finally, the auxiliary energy consumed by pumps, fans and control & actuators is generally speaking more or less taken into account.

## 3 > Calculation methods: summer comfort

Of the 9 countries that had an EPB-regulation at the time of the enquiry, 5 reported that the regulation included some kind of evaluation of the summer comfort. But the summer analysis did not necessarily apply to all types of buildings. Usually, an explicit requirement was associated with the analysis. The detailed situation was as follows:

- Belgium:
  - dwellings only (whether with or without air conditioning)
  - a maximum allowable value is imposed
  - if the indicator is in the range between a threshold and the maximum, fictitious cooling consumption is taken into account
- France:
  - all non air-conditioned buildings
  - a maximum allowable value is imposed (namely that of a reference building with reference technological measures)
- Germany (in the form of a "solar gains indicator"):
  - dwellings only
  - a maximum allowable value is imposed
- Ireland:
  - both domestic and non-domestic
  - no maximum, only as indicator
- the Netherlands:
  - dwellings only (whether with or without air conditioning)
  - no maximum, only as indicator
  - there is always fictitious cooling, only depending on the cooling needs, independent of the overheating indicator

In several of these countries, there was work in progress to extend the method, e.g. to all types of buildings.

Apart from a few exceptions, the same variables as for cooling calculations are considered for evaluating the risk of overheating on "room" level. However, none of the countries incorporates as yet passive cooling techniques with a central heat dump (ground, surface water, ambient air through a heat exchanger etc.) in the overheating analysis.

## 4 > Requirements

In addition to an overall EPB-requirement, there may be requirements specifically related to summer comfort and air conditioning. These requirements can cover global, intermediate or individual aspects of the building performance. The actual values are commonly dependent on the climatic zone and/or the building type. The requirements of a certain country can include simultaneously limiting values of different aspects and/or at different levels.

The most global level refers to the overall energy performance of the building, in which the cooling energy (or $CO_2$ emissions for cooling) is included. The minimum requirement is expressed as a limiting value of the overall energy consumption (or of the $CO_2$ emissions) of the building.
The second level covers the energy efficiency use by use. In this case a minimum efficiency of the combined effect of the building envelope and the cooling system is fixed. Consequently, if the building is air conditioned, the minimum requirements, at this level, can be referred to limiting values of:

- Cooling energy consumption (final or primary energy).
- $CO_2$ emissions for cooling

In a third level the effect of the envelope and the HVAC systems can be independently limited. In this level, if the building is air-conditioned, the minimum requirements can refer to:

- Maximum cooling needs allowed.
- Minimum efficiency (probably nominal EER) of the cooling system allowed.

Alternatively, if no cooling system exists, the minimum requirements can refer to an overheating indicator. In this case, the limit value of the indicator is used to demonstrate that cooling will not be necessary.

Another possible requirement at this level is to fix a certain percentage of the cooling needs that have to be covered by renewable energies.

In the fourth level, the cooling demand (or the overheating) is limited in a very indirect way, by limiting some relevant parameters that influence them, such as:

- A reduction of the solar gains
- A modulation of the solar gains
- A dissipation of the solar and internal gains via ventilation losses.

In the ASIEPI project, a survey has been made regarding present summer comfort and energy requirements in the national building regulations. A summary of the results can be seen in the table below, for the four levels of requirements previously described. A more detailed description is given in ref. [3].

In general, it can be seen that cooling is included in the global requirement as a source of energy consumption or $CO_2$ emissions.

However, no country has specific requirements regarding cooling as an independent energy use and only two countries (Spain and Portugal) include a limitation of the cooling needs of the building. Greece is the only country that states specific requirements with respect to the efficiency of cooling machines (i.e. a minimum EER for each type of device, e.g. for split units, for air cooled chillers, etc.). In Spain, there is under certain conditions an obligation to incorporate free-cooling and/ or recuperation of the energy in the exhaust air.

| | Spain | Netherlands | Belgium | France | Portugal | Germany | Poland | Italy | Greece | U.K. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Limitation of the overall energy performance or $CO_2$ emissions of the building including cooling | NO | YES | YES | YES | YES | YES | NO | NO | YES | YES | 7/10 |
| 2. Independent limitations for cooling | NO | NO | NO | NO | NO | NO | NO | NO | NO | NO | 0/10 |
| 3.1 Limitations of the cooling needs | YES | NO | NO | NO | YES | NO | NO | NO | NO | NO | 2/10 |
| 3.2 Prescriptions regarding the use of renewable energies for cooling | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO | 1/10 |
| 3.3 Requirements regarding the efficiency of cooling system | YES | NO | NO | NO | NO | NO | NO | NO | YES | NO | 2/10 |
| 3.4 Requirements regarding summer comfort in case of non-air conditioned buildings | NO | NO | YES | YES | NO | YES | NO | NO | NO | NO | 3/10 |
| 4.1. Limitations of the glazed area | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO | 1/10 |
| 4.2 Requirements regarding solar protection | YES | NO | NO | YES | YES | YES | YES | YES | YES | YES | 8/10 |
| 4.3 Other requirements for summer comfort | NO | NO | NO | NO | NO | NO | NO | YES[1] | NO | NO | 1/10 |

An issue warranting particular attention is the treatment of summer comfort. Only Germany (for non-air conditioned buildings) and Belgium (for dwellings) have explicit limitations of the overheating. France addresses an indirect limitation of the overheating risk via the reference building.

In other countries, for non-air conditioned buildings, avoiding overheating is vaguely treated in the form of recommendations but not as a mandatory issue. In some countries when overheating appears, there is a penalty of the energy consumption via a virtual cooling system.

Although solar control is mentioned in most questionnaires, specific mandatory solar control requirements are only explicit in two of the countries, namely Germany and Portugal.

In general, it seems that although the concepts to be dealt with regarding summer comfort and cooling are known, fixing them as mandatory requirements is a very difficult (or unnecessary) task and recommendations are largely preferred. This is the case for issues such as night ventilation or thermal inertia which do not appear as requirements but as recommendations except in Italy where thermal mass is required beyond certain levels of mean irradiance during the hottest month. This position is quite understandable due to the fact that both issues are time dependent and very difficult to quantify in a consistent way.

Even the relative approach which defines the requirements via the reference building can also be seen as a way of providing recommendations about how to get the target. The real building can completely ignore such recommendations and compensate the extra cooling with other energy uses.

From the table it is clear that the countries strongly focus on solar protection as requirement. All other potential levels get much less attention.

[1] See in the text for further explanation.

## 5 > Summary and recommendations

### Cooling calculation methods

Although a good deal of attention is already given to the consumption for cooling in the national/regional EPB-regulations, the methods usually cannot fall back on the same decade-long experience and detail that exists for space heating calculation methods in the framework of regulations. Generally speaking, the continued further refinement of the methods is therefore warranted so as to better evaluate the consumption of all possible means of cooling, including and in particular the low energy methods.

By not giving an extra allowance for the maximum allowed primary energy consumption in the case active cooling is applied (as compared to the situation without active cooling), the countries can stimulate that a cooling system as efficient as possible is applied and/or that the extra consumption for cooling is compensated for by extra savings in other domains (heating, lighting, etc.). All but 2 of the surveyed countries report to already follow this approach.

In addition, nearly half of the countries also consider a kind of fictitious cooling in some way or another. In this instance, even though no active cooling is installed, a (fictitious) consumption for cooling will nevertheless be considered, in particular when the risk of overheating is high. This takes into account that cooling may be installed later on during the life cycle of the building. It thus stimulates that also in buildings without active cooling proper attention is given to the summer situation, and that the design does not focus exclusively on minimising space heating needs in winter (through maximising solar gains), to the detriment of summer comfort. The inclusion of fictitious cooling also facilitates the application of the above rule that the EPB-requirement is made independent of whether or not active cooling is installed. It can thus be advised to all countries to consider whether integrating such fictitious cooling could also be productive in their country.

With respect to the calculation procedures, it is important that all aspects that have an impact on the cooling consumption, are integrated in the methods, in particular those variables that can contribute to the reduction of the consumption and that are cost-effective in a given country. Practically speaking, the following techniques are not yet well developed in the calculation in many countries and these techniques may deserve priority attention:

- Intensive ventilation, taking into account the sizing and real performance characteristics of the components (e.g. the flow features of ventilation openings). The new European standards that have been developed in recent years on this topic may provide a good starting base for national procedures.
- Active cooling devices (whether electrically or thermally driven) often still deserve better treatment by the inclusion of real product characteristics in the methods (EER, or better SEER) instead of simple, fixed performance numbers.
- Also, natural, passive cooling is not yet well developed for central heat dumps (thus discharging the cooling machines, or even making them superfluous).
- Further more, a great number of smaller variables are not yet systematically considered in the methods. These should not be forgotten in any future update of methods.

Attention should also be paid to the proper setting of default values, which by nature are on the negative side in most countries. However, what is negative may differ between heating and cooling calculations, and so a differentiated approach is often justified, certainly for the variables that have a major impact, e.g. air tightness and thermal bridges. In this manner, the right rewards continue to be given to proper design choices.

**Evaluation of the summer comfort**

About half of the countries surveyed already include some kind of evaluation of the risk of overheating in their EPB-regulation, but none of these countries is a truly Mediterranean country. However, the analysis was rarely systematic for all types of buildings.

It can be recommended that those countries already having an overheating analysis evaluate whether it isn't appropriate to extend it to all buildings (if not yet done so) and to include forms of central passive cooling.

The other countries can be advised to investigate whether an overheating analysis could not be useful for them too. It may be a means to strongly stimulate the attention which is being paid during design to the summer situation. In addition, it will draw attention to the passive cooling means to avoid overheating. Thus, the chance that an active cooling system will be installed later on in the building life cycle, can be reduced, and if it happens nevertheless, the cooling consumption will be much lower if the building has been designed with due attention to the summer situation.

**Requirements**

In order to reduce the energy consumption for cooling and to promote the use of passive cooling concepts and strategies and in order to anticipate undesirable effects of global warming, it is strongly recommended to set:

- A global requirement of energy consumption and/or $CO_2$ emissions in which cooling must be obviously included.
- Additional requirements limiting the cooling needs for air-conditioned buildings.
- Additional requirements for non-air conditioned buildings limiting the overheating risk or, in a complementary way, clear indicators that allow identifying the necessity or not of air conditioning (for both residential and non-residential buildings).
- The inclusion of such indicators about summer comfort should be based on indoor temperature levels consistent to the adaptive comfort criteria of EN 15251.
- If practically feasible in the context of the national EPB-regulation, the inclusion of such indicators about summer comfort should be based on hourly calculations of the indoor temperatures at a zone level, due to the huge temperature differences that can exist between zones of the same building.

The use of additional requirements on a component level (shading factors) or the necessity of using certain strategies (ventilation rates or thermal inertia) is not recommended in general. It is considered that requirements that are too prescriptive reduce the free choice for alternative methods that may achieve the same result and that may be better feasible in a given individual project (in terms of practical application, cost effectiveness, personal preferences of the owner, etc.).

The use of the absolute (fully performance) approach or the relative (reference building) approach to state the requirements have no specific aspects for cooling or summer comfort. Consequently, there are no special recommendations about the way of defining the requirements.

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## 6 > References


1. D. Van Orshoven, "ASIEPI survey of the EPB-determination methods for cooling and summer comfort." XL-file. Published February 2010.
   see: *www.asiepi.eu*
2. A. Van Eycken, D. Van Orshoven, G. Flamant, P. Wouters
   "Some Aspects Regarding Summer Comfort and Cooling in Belgium"
   Presented at the international workshop, "Summer comfort and cooling", Barcelona, Spain - 31 March & 1 April 2009
   see *http://www.asiepi.eu/wp-7-summer-comfort/workshop.html*
3. Servando Alvarez , ASIEPI report "Additional requirements related to summer comfort and air conditioning" Published January 2010.
   see: *www.asiepi.eu*



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